MEMORIAL

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ON INDUSTRIAL FELLOWSHIPS.

In accordance with the invitation of the editor of THIS JOURNAL, I append a statement of a scheme of Industrial Fellowships which was initiated by me in an article entitled "[Temporary Industrial Fellowships," in the *North American Review* for May, 1907, and which appeared subsequently as the last chapter in a book intended to draw the attention of American manufacturers to the applicability of modern science to industrial operations ("The Chemistry of Commerce," *Harper's*). During the last two years this scheme has undergone a somewhat notable development not only in the number and value of the fellowships established, but, as well, in the increased advantages which I have found it practicable to obtain from the donating corporations in behalf of the university. It should be plainly stated, however, that the scheme is as yet inevitably experimental and tentative and that each individual fellowship must always, from the very nature of the case, be an experiment. It is not pretended either that the scheme in its details has reached its ultimate development; all that can be siad is that during the past two years it has shown no sign of weakness on the part of any one of its constituent factors but has, on the contrary, grown constantly stronger.

Before entering into the details of the scheme itself, it may be of interest to state here the fundamental considerations upon which it was based. In advancing them there is no thought of attempting to speak dogmatically; they are simply personal convictions which account for the scheme.

(1) It is not the function of a professor of industrial chemistry *in a university* to establish courses and laboratories for undergraduates who propose to become chemists, and for the following reasons: Current industrial practice is always ahead of text-book presentation and laboratories of industrial chemistry having apparatus and processes in miniature are for the most part puerile in their resultant teachings and convey to the student an exaggerated impression of his utility to the factory to which he subsequently goes. Worse than all is the fact that in taking such courses the chemical undergraduate is deprived of just so much pure chemistry, *i. e.*, real chemistry. The university insists that the chemical undergraduate shall undertake cultural and cognate studies. The result is that in taking industrial chemistry he must omit a particulary good course in physical chemistry or he must remain with half a year in organic rather than with a full year, or he must squeeze his training in combined qualitative and quantitative analysis within a year or a year and a half. If the university does not insist upon cultural studies the resultant "[Chemist]" might as well be called a cook for any claim he may have

to recognition as an educated man. The foregoing considerations do not apply to trade schools or to technical schools. The function of a university is to free men to the exercises of their maximum powers; in a trade school the young man enters already limited.

(2) Speaking with whatever truth there may be in generalities, the condition of American manufacture with respect to progressive and correct factory practice and with respect to genuine efficiency is seriously bad. (I am referring not to the mechanical but to the chemical phase of manufacture.) The necessity for this progress and efficiency in the past two or three decades has been marked by certain factors. These appear to have been a wealth of raw material everywhere at hand, an excessive tariff that concealed from the manufacture the practical presence of his problems, a certain facility possessed by the American manufacture for what may not unfairly be called business intrigue, which enabled him to supplement the waste in his factory by combinations for the elimination of competition, and, finally, the needs of a rapidly expanding population which would swallow anything. Two years ago, however, conditions were rapidly changing. The unexampled and wasteful production of the country was bidding fair to result in overproduction; in the practice of business intrigue no manufacturer had anything to learn from another; the wealth of raw material had in a large measure been aggregated into the holdings of a few men who would release them only at an onerous and distressful rate; the tariff, high as it was, was unable to exclude many articles made under scientific supervision, and the tariff, itself, lay and lies in increasingly unstable equilibrium. These facts convinced me that American manufacture was approaching a crisis and that there would soon be a realization that safety in manufacture could be gained only through efficiency. I may say here, that this conviction has been amply substantiated during the last two years. Few men have any idea of the ever-increasing anxiety of American manufacture to secure factory efficiency. It may safely be predicted that during the next five years the supply of research chemists will be wholly inadequate to the demand; it is, indeed, today.

(3) The American manufacturer has neither the knowledge nor the experience requisite for the establishment of successful scientific research.

(1) He does not know what problems he has, nor their relative importance.

(2) He does not know what kind of knowledge is required to solve these problems.

(3) He does not know how to go about it in order to obtain the men who are really expert in the different kinds of knowledge requisite to the solution of these problems.

(4) He does not know how to judge the qualifications of

training and creative power among the different men available; he frequently, for example, chooses an analyst when a synthetic man is required and *vice versa*.

(5) He does not know how to estimate a proper expenditure for laboratory space and supplies and library facilities which these men will require on the basis of the least money for the largest efficiency.

(6) He does not know how to coördinate the work of these men with the factory operations.

(7) He does not know how to coördinate the work of the researches on his staff, one with another, so that they will be mutually helpful one to another.

(8) He does not know how properly to estimate the progress made by these men so that he may know when he is getting real efficiency.

(9) He does not know how to systematize the work of his scientific staff so that it will work automatically.

(10) He does not know how to treat a man of science in his factory in giving him either power or trust.

This last consideration is responsible for much of the failure of American factory research. The condition of the research chemist in the American factory is often actually pitiful and may be compared to that of cultured governors in a home of codfish aristocracy.

Whatever the foregoing generalities may be worth, and they are, of course, merely personal convictions, they are, taken together, responsible for a scheme by which in a spirit of sympathetic coöperation the university and the manufacturer might each profit—and the public through both—a scheme of Industrial Fellowships. This scheme in its present development is perhaps best exploited by presenting here one of the later fellowships; for example, Fellowship No. 7. It will be understood that the fellowships differ one from another, owing to the particular conditions relating to each and owing, occasionally, to the idiosyncrasies of the donor.

Fellowship No. 7.—For the purpose of promoting the increase of useful knowledge, the University of Kansas accepts from the A. B. C. Glass Company, having head offices at New York, the foundation of a temporary industrial fellowship to be known as the A. B. C. Fellowship.

It is mutually understood and agreed that the conditions governing this fellowship shall be as follows:

The exclusive purpose of this fellowship is an investigation into the optical properties of glass in relation to its chemical constitution to the furtherance of which the holder shall give his whole time and attention, with the exception of three hours a week which he shall give to work of instruction in the chemical department.

The fellow shall be appointed by the chancellor of the university, the director of the chemical department and the

professor of industrial chemistry; he shall have made previously a reputation in research; he shall be a member of the university, and shall pay all regular fees with the exception of fees for laboratory and supplies, for which his instruction shall be taken in lieu, unless in the opinion of the appointers his demands become excessive, in which case the donor shall be expected to reimburse the university; he shall work under the advice and direction of the professor of industrial chemistry; and he shall forward, periodically, through the professor of industrial chemistry, reports of the progress of his work to the A. B. C. Company.

For the support of this fellowship, which shall extend through a period of two years from the date of appointment of the fellow, the A. B. C. Glass Company agrees to pay fifteen hundred dollars ($1500) per year, payable annually, to the university on the date on which the fellow begins work at the university. This sum shall be paid by the university in monthly instalments to the holder of the fellowship.

Any and all discoveries made by the fellow during the tensure of this fellowship shall become the property of the A. B. C. Glass Company, subject, however, to the pavement by them to the fellow of ten (10) per cent. of the net profits, to be commuted at the desire of either party through the arbitration provided for herein, arising from such discoveries, it being understood that the fellow shall be regarded as the inventor. At any time during the tensure of his fellowship the holder shall, at the option of the donor, take out patents at the expense of the donor on condition that at the time of making application therefor he shall assign his right to the donor under the conditions of this agreement. At or before the expiration of the fellowship, the business services of the fellow may be secured by the A. B. C. Glass Company for a term of three years on condition that the terms of such services are satisfactory to both parties at interest.

In the event of any disagreement between the donor and holder of this fellowship, it is understood and agreed that the chancellor of the university, or one whom he may appoint, shall act as arbiter as to all matters of fact, that his decisions shall be binding upon the parties at issue, and that they shall obtain such decision before having recourse to the courts.

It is also understood and agreed that during the tensure of this fellowship the holder may publish such results of his investigation as do not, in the opinion of the company, injure its interests, and that on the expiration of the fellowship the holder thereof shall have completed a comprehensive monograph on the subject of his research, containing both what he and others have been able to discover. A copy of the monograph shall be forwarded to the A. B. C. Company, and a copy shall be signed and placed in the archives of the university until the expiration of three

years from that date, when the university shall be at liberty to publish it for the use and benefit of the people.

Signed on behalf of the University of Kansas.

.....

Date.....

Signed on behalf of the A. B. C. Glass Company.

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Date.....

A careful reading of the above agreement, or perhaps it had better be called, memorandum, may make apparent certain relations (1) to the university; (2) to the manufacturer; (3) to the fellow; (4) to the public; (5) to the professor of industrial chemistry.

(1) (*a*) The university gains increased opportunities of fulfilling its function in promoting research. (The fact that the research has directly useful ends in view does not make it necessarily any the less scientific or valuable.) (*b*) It obtains three hours a week of gratuitous instruction from men particularly well qualified from the standpoint of ability, knowledge, and enthusiasm to give it. (*c*) The chemical department of the university obtains the catalytic influence of these men.

(2) (*a*) The manufacturer obtains the advantages of enormously increased laboratory facilities. (*b*) He obtains the advantage of adequate library facilities—a most important advantage, the lack of which has seriously hampered much factory research. (*c*) He obtains consultive advantages, for the fellow appointed is at liberty to go with direct or hypothetical questions to specialists in the different fields of chemistry or to specialists in other fields of scientific knowledge, such as biology, physiology, physics, etc. This has also turned out to be an important advantage. (*d*) He obtains a complete freedom from supervisional responsibility over this work. (*e*) He obtains on the termination of the fellowship the services of a man educated to his particular needs.

(3) The fellow obtains all the foregoing advantages (*a–b–c*) ascribed to the manufacturer, and in addition he obtains (*d*) the all-important sympathetic coöperation of the manufacturer together with the (*e*) inside knowledge of the factory processes, and (*f*) the university's environment sympathetic to research, and (g) a freedom from all petty interferences and jealousies of shop people, and the pot-shot judgments of factory officials. Finally, if he proves worthy of it, he obtains a position for which he has become, through his training, peculiarly qualified.

(4) Since at the end of three years all work done under any fellowship must be published free to the public, the public thus obtains new implements of civilization. It must be remembered that it is only through the industries that any useful discovery can go to the people.

(5) Since this whole scheme depends upon sympathetic

coöperation it can only be carried out through a professor of industrial chemistry who regards it as a sacred trust. It is, therefore, necessary, positively necessary that the professor of industrial chemistry should, so far as any material sense is concerned, gain absolutely *nothing*, otherwise his donors would not trust him with the details of their secret processes, nor would his fellows trust him with their progress.

There have been so far accepted by the university the following fellowships:

(1) An Investigation into the Chemistry of Laundering, having for its object an improvement which will save in some measure laundered fabrics. It yields $500 a year, together with 10 per cent. of the net profits.

(2) A Search for a New Diastase. The present source of the best diastase is expensive. The investigation has as a matter of fact developed into an attempt to make a new fodder upon scientific principles. It yields $500 a year and, under the original agreement, 10 per cent. of the gross proceeds for three years.

(3) An attempt to Utilize the Constituents of Waste Buttermilk, which, at present, in butter factories goes down the drains. These constituents, which it is desirable to conserve, are primarily caseine, and secondarily, lactic acid and sugar of milk. The fellowship yields $500 a year and 10 per cent. of the net profits.

(4) An Investigation into the Chemistry of Baking. This investigation was established by the National Association of Master Bakers, with the object not only of improving the chemistry of bread, but, as well, of providing for the association a trained expert upon whom they could afterwards rely. It yields $500 a year, together with a lump sum to be settled by arbitration, if necessary.

(5) An Investigation into the Constituents of Crude Petroleum. I cannot with propriety state the precise object of this investigation. The fellowship yields $1,000 a year, and 10 per cent. of the net profits.

(6) An attempt to Improve the Enamel upon the Enamel-lined Steel Tanks used in all kinds of chemical operations on a large scale. This fellowship was established by the largest manufacturer of these tanks in the world. It yields $1,300 a year, together with an additional consideration to be decided upon, for the service rendered by the chancellor of the university or one whom he may appoint.

(7) An Investigation into the Relation between the Optical Properties of Glass and Its Chemical Constitution. This fellowship yields $1,500 a year and 10 per cent. of the net profits.

(8) The Discovery of New Utilities for Portland Cement and of Improvements in Its Manufacture. This fellowship yields $1,500 a year and a large additional consideration dependent upon success.

The fellows for additional Fellowships Nos. 7 and 8 have not yet been selected. In addition to the foregoing fellowships there are certain others assured but not yet established.

(9) An Investigation into Certain Glands of Deep-sea Mammals. It yields $1,500 a year and an additional consideration to be decided upon by arbitration. This fellowship is to be a benefaction.

(10) The Discovery of New Utilities for Ozone. It yields $2,000 a year and 10 per cent. of the net profits.

The tensure of all fellowships is two years.

It is regrettable that in accordance with the terms of the agreement, it is impossible to publish at this time the results so far obtained. It may be said, however, that the progress of the fellows has been gratifying. It is significant in this connection that Fellowship No. 1, which expires shortly, is to be continued at double the value for three months, at the end of which time the donors will either take the fellow and his process into the factory or they will continue his fellowship through a third year at the increased amount, while with Fellowship No. 2 the donors have already indicated their intention to continue it throughout a third year; the progress of the others has exceeded that of the first two and has surpassed expectations.

Most of these fellowships have arisen through letters of inquiry from the various companies. I have not gone out seeking fellowships in general. Had I done so it is not unreasonable to suppose that by this time there might have been from thirty to fifty. Owing to the fact that these fellowships have no relation to ordinary fellowships and that the scheme is essentially a new one, it has been deemed advisable to establish them at intervals. Proceeding in this way, and learning as one went, the scheme has undergone a natural and advantageous development. The degree to which it has been systematized, its effect upon the chemical department, the results of the relations of the different researches and researches to one another, and the wholly unexpected interactional relation to the donating companies to one another I shall reserve for a future communication. While it should be said that as yet this scheme of Industrial Fellowships is wholly experimental and tentative, it ought also to be said that the two years' experience has not shown that it is any other than a sane and practical relation between the university and industry to the advantage of all concerned.

ROBERT KENNEDY DUNCAN.

UNIVERSITY OF KANSAS,
May 12, 1909.

DEPARTMENT OF CHEMISTRY.

ROBERT KENNEDY DUNCAN,
Professor of Industrial Chemistry.

Fellows in Industrial Chemistry:
F. W. FARAGHER, A. B.
R. C. SHUEY, B. S.
H. A. KOHMAN, A. B.
E. L. TAGUE, A. M.
F. W. BUSHONG, PH. D.
ARCHIE J. WEITH, B. S.
FRANK P. BROCK, B. S.
E. WARD TILLOTSON, PH. D.
J. F. MACKEY, PH. D.
E. R. WEIDLEIN, A. B.
L. V. REDMAN, PH. D.
B. C. FRICHOT, B. S.

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THE UNIVERSITY OF KANSAS.
LAWRENCE. April 9, 1910.

All letters concerning the investigative work in Industrial Chemistry should be addressed to Professor Duncan.

For Careful Transmission to the Chemical Department.

Dr. Robert Falconer,
President of the University of Toronto,
Toronto, Canada.,

Dear Dr. Falconer:-

I am enclosing with this some data concerning my Industrial Fellowships which may be of interest to you. These Fellowships are now no experiment but a proven success. They are, however, growing so numerous that they have completely transcended the facilities of the University of Kansas, and I am wondering whether it might not be possible for you to take them under your aegis.

In addition to the Fellowships already established, I have not less than thirteen pending: six on the chemistry of crude petroleum, six to cover the whole field of enamel in all its phases, and one concerning the synthesis of a new alkaloid, which it is proposed to make $2,000. a year. The other multiple Fellowships of which I have spoken ought to yield collectively $8,000. a year each. Of course you have no room, but I suppose there is no question but that if I were with you it would be easily and readily possible

to quietly and inconspicuously obtain a building and equipment for you, for this purpose. As a matter of fact, I have not the faintest doubt as to the possibility of my doing this.

If the idea is at all appealing to you, it would confer a great pleasure upon me if you would let me know at once, owing to the fact that I anticipate receiving, in the immediate future, a call to one of the great eastern universities. I should, however, very much prefer to take this work to the University of Toronto. I am a graduate of Toronto of '92 and naturally have, not only a very deep love for the University itself, but have a great deal of my Canadianism still left. I am convinced that it would do an enormous good to Canada and to Canadian interests and, just as much to the University of Toronto. My object now is to obtain a building in which I can place at least forty real chemists, involved in problems of highest scientific and industrial importance. Forty men of this type, working with the proper spirit and with the proper facilities, would hardly accomplish anything other than a notable achievement.

Hoping that the idea will appeal to you, and that you will let me know at your very earliest convenience, I am, Sir.

Respectfully yours,

Robt. Kennedy Duncan

RKD-MCB.

encl.

No. 1.

Supplementary Data Concerning Industrial Fellowships.

Feb. 21, 1910.

1. Various corporations, mostly eastern, have placed with me during the past two years the amounts as given below for direct expenditure in research, and from the knowledge I now possess there is no apparent reason why the amount should not be readily trebled.

Fellowships and Contributions.

Fellowship No. 1.	$1,500.
" " 2.	1,500.
" " 3.	1,000.
" " 4.	1,000.
" " 5.	2,000.
" " 6.	2,600.
" " 7.	3,000.
" " 8.	3,000.
" " 9.	1,000.
" " 10.	3,000.
" " 11.	750.
W. R. Nelson Prize	200.
Optical Company's Prize	100.
Ozone Plant	500.
National Laundry Machinery Co., Plant for Commercial Electrolysis	200.
Establishment of Bureau of Research for an eastern corporation	2,500.
Investigation of Camphor growing in Jamaica	2,000.
Gifts of Apparatus, travelling expenses of Fellows, etc. more than	1,000.
Total	26,850

2. The expense to the Department for material consumed is less than the interest on the Fellowship money in the treasurer's hands.

Supplementary Data No. 1. continued.

3. Thw expense for the purchase of necessary permanent apparatus has been more than met by free gifts from the donors of the Fellowships and others quite outside of the Fellowship money.

4. The gratuitous instruction given by my Fellows in the different branches of chimistry in the Chemical Department, exceeds 30 hours a week and it is given, of course, by highly trained and competent men.

5. I have found in the universities, both here and abroad, an intense interest in the department and an eagerness on the part of the best research workers to obtain the Fellowships at my disposal.

6. The work of obtaining researchers of high standing and of conducting researches has been systematized.

7. The scheme has proved to be fully in accord with university ideals and at the same time wholly satisfactory to donors and researchers alike.

DEPARTMENT OF CHEMISTRY.

ROBERT KENNEDY DUNCAN,
Professor of Industrial Chemistry.

Fellows in Industrial Chemistry:

F. W. FARAGHER, A. B.
R. C. SHUEY, B. S.
H. A. KOHMAN, A. B.
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J. F. MACKEY, PH. D.
E.R.Weidlein, A.B.
L.V.Redman, Ph.D.
B.C.Frichot, B.S.

THE UNIVERSITY OF KANSAS,
LAWRENCE.

All letters concerning the investigative work in Industrial Chemistry should be addressed to Professor Duncan.

No. 2.

Supplementary Data Concerning Industrial Fellowships.

Feb. 21, 1910.

In accordance with the terms of the Fellowship agreements it is impossible to divulge the detailed progress of any Fellow until three years after the termination of his Fellowship. Something, however, may be said in general terms concerning the progress of these Fellowships.

Date of establishment of the first Fellowship, May, 1907. The others were established at intervals of a few months, in the order following.

No. 1. The Chemistry of Laundering.

At the end of the tenure of this Fellowship, the Fellowship was doubled for six months. The Fellow is now with the donating corporation.

No. 2. On Diastase.

This Fellowship has been continued through a third year. It has developed into a research concerning the construction of a scientific fodder. In this Fellowship the Fellow has discovered that alfalfa is particularly interesting from the standpoint of its diastatic content and its cytase. He has further discovered a method by which this high diastatic

Supplementary Data No. 2. Continued.

content may be readily conserved in drying alfalfa, and to such an extent that it bids fair to enormously increase the value of alfalfa as a fodder. We are at present proceeding to test out the value of this discovery on a large scale in the feeding of sheep.

No. 3. The Chemistry of Bread.

The Fellow concerned in this work has already accomplished two pieces of work of considerable significance.

(a) He has discovered a method for the utilization of stale bread in the manufacture of new bread, and:

(b) He has succeeded in standardizing the manufacture of salt-rising bread, and in rendering it possible to manufacture it on a large scale, of the same quality day after day. In order to do this work it was necessary for him to discover the particular bacterium concerned in the manufacture of salt-rising bread. This bacterium is not yeast as was formerly believed. After discovering the bacterium he succeeded in isolating it and in forming a pure culture. He has since succeeded in growing this culture on a large scale, so that it is now capable of taking its place on the market for the general purpose of making salt-rising bread of a quantity however large and of uniform and improved quality.

No. 4. The Extraction of Utilizable Constituents from Crude Petroleum.

Since crude petroleum is in the position of coal tar in the early 50's, we could, of course, employ a dozen researchers in this one work. The Fellow concerned has made remarkable progress, and has finally succeeded in isolating definite compounds of the cyclic series from crude petroleum, in consider-

able quantities and is at present engaged in their identification.

No. 5. The Utilization of the Constituents of Waste Butter-Milk from the Butter Factories.

For a year and a half the Fellow on this research worked without positive success. Owing to the enormous difficulties of his task his final success is a highly creditable achievement. No man has up to this time succeeded in isolating casein from butter-milk in such a condition that it is positively identical with the casein from skim milk. The problem has been solved in these laboratories and on a commercial basis, through rigorously scientific methods. We are now manufacturing large quantities of casein from butter-milk, which, in accordance with the statements of consumers of casein, is identical with that from skim milk. The success of this one operation ought to add millions to the property of the country.

No. 6. On the Betterment of Enamel for Enamel-Lined Steel Tanks used in all kinds of large scale industrial operations.

This Fellowship, which is held by two men, has succeeded in creating an enamel which lies beautifully on steel and which is more resistive than any other enamel so far made for any purpose whatever. It has been subjected to the action of the most energetic acid solutions and has for several months resisted them to the extent that it shows no signs whatever of their attack. The Fellows concerned are now manufacturing large quantities of this enamel, and will proceed in a few weeks to their donors to carry out its large scale application.

No. 7. On the Relation between the Optical Properties of Glass and its Chemical Constitution.

Supplementary Data No. 2. Continued.

This Fellowship was concerned at first with the creation of a glass with a particularly high index of refraction. Such a glass is needed by the donors of this Fellowship for large scale manufacture. While the Fellowship has been in existence only since September, 1909, this glass has already been discovered, and we are now only awaiting the receipt of a press and moulds, in order to manufacture a considerable number of articles from it. As a side line, however, to this research, the Fellow has devised an exceedingly interesting and wholly novel method for the measurement of surface tension of molten glass, and is carrying it out to the accurate and complete discovery of the laws concerning it.

No. 8. On the Manufacture of Cement and Lime.

This Fellowship went into operation only last November. Our first step was to send the Fellow on a tour of investigation among the cement plants of this country. On his return we decided to attack the problem of the large scale manufacture of hydrate of lime which is in an exceedingly unsatisfactory condition. The Fellow has already proved that the hydrate of lime manufactured on the large scale is crystalline in structure, while the hydrate of lime made on the small scale in house buildings operations, is amorphous, and he is now engaged in retarding this large scale crystallization in order to make the two products identical. Sufficient time has not elapsed, of course, for him to have succeeded.

No. 9. An Investigation into the Ductless Glands of Deep Sea Mammals.

This Fellowship begins its work on the first of

March. It is proposed that by the first of June the Fellow will have mastered the technique concerning the experimentation of the study of these glands. He will then proceed to the Labrador where, with the aid of Dr. Wilfred T. Grenfell, he will collect material for his subsequent investigations and will at the same time make a study of these glands, particularly as they occur in the whale. He is proposing to make a comparative study of the extractive principles of the supra-renal glands, the thyroid glands, the thymus glands and the pituitary body of whales, as compared with the land mammals, and if he has time will extend his study to that of other deep sea mammals, such as that of the seal.

No. 10. On the Chemical Treatment of Wood.

The Fellow appointed to this work, as is the case with Nos. 7 and 8, is a Doctor of Philosophy, chosen from one of the great universities, and backed by the whole university concerned. It is, of course, too early to pronounce anything at all concerning its progress.

No. 11. On the Discovery of New Utilities for Borax.

The Fellow concerned in this work has occupied his Fellowship not more than a month and it is, consequently,, too early to have attained results.

In considering the measure of success so far achieved by these Fellowships, too much stress cannot be laid upon the value of the sympathetic cooperation existing between the factories of the donors of these Fellowships and the Fellows working here with the facilities of the University.

Supplementary Data No. 2. Continued.

In addition to the work of the Fellowships outlined above during the last two years, the head of the Department of Industrial Chemistry has had the responsibility of establishing in one of the great eastern corporations, a Bureau of Chemical Research, and he has also recently been called to the Island of Jamaica to investigate the validity of the camphor growing industry in that Island, all this work, of course, being carried out here at the University.

SUPPLEMENTARY DATA NO. 3.

I.- Do the Industrial Fellowships tend to promote the enlargement of chemical knowledge?

(a) I should not care to recommend for acceptance any Fellowship which when properly conducted was not reasonably sure to result in the acquisition of important new chemical knowledge.

(b) The objects of the Fellowships are always stated in the agreements in the broadest general terms and no donor has attempted to dictate in the slightest degree the line which any investigation should take, nor would such dictation be tolerated.

(c) The methods we employ in this work lead inevitably to new knowledge. It is our regular custom not to attack these industrial problems from the inside (i.e. from the traditional knowledge of the art) but always from the outside. This, I have advisedly refused to take a cement man for a cement investigation, or a glass man for a glass investigation but instead men splendidly trained in contemporary chemistry with a proven ability in research. As an example of our method, - in the Fellowship concerned with the chemical treatment of wood, we have decided to initiate an attack on the finish on the surface of wood by making it better and by making it more resistive to mechanical impacts and to chemical agents, such as alcohol, acids, etc. - all this for the finish on automobiles, boats, railway carriages, etc., I have directed the man

(1) to absorb the current knowledge of varnish, etc.

(2) to go into a factory and learn to varnish.

(3) to visit and study half a dozen varnish factories.

(4) to make a series of varnishes.

(5) to read and study thoroughly all the abstracts during the last six years relating to varnish and allied material.

(6) after the accomplishment of this preliminary work to study the "pure science" Abstracts for the last five years with an eye single to the application of absolutely new facts to the finish of wood.

It is upon this (6) that I rely for success, and experience with other Fellowships is proving that this course is correct. It must be remembered though that it is this "outside" attack that leads to new knowledge.

(d) These Fellowships have and are actually extending

Supplementary Data No. 3. Continued.

chemical knowledge. Thus, for example, the investigator in Petroleum is far and away beyond current chemical knowledge in the constituents of Petroleum. He has, as a matter of fact, succeeded in opening up a hitherto unknown field for chemical investigation to such an extent that I now propose to establish six Fellowships to enter this field: three of them at $1,500 a year and three at $750. These six will work under his control. I have not yet established these Fellowships simply because I have not room. I can do it practically at any time.

Again, in the case of the investigation into enamel. The discovery of an enamel by the Fellowships concerned with a resistivity far greater than any so far known either to industry or science depends upon new chemical knowledge. The present donors of this Fellowship have earnestly requested permission to establish through the cooperation of manufacturers engaged in wholly ~~types~~ of enamel, a half dozen Fellowships in order that the whole field of enamelling from jewellery to cooking utensils may be investigated through a series of years.

Again, there is the case of the Fellow concerned with the relation between the optical and chemical properties of glass. While his first main business was the construction of an industrial glass with a peculiarly high coefficient of refraction, he has developed from the standpoint of pure science an absolutely new and rigorously accurate ~~quantitative~~ method of investigating a factor connected with glass and other meltable colloidal bodies, about which virtually nothing is known.

The Fellow concerned with Bread in succeeding in standardizing salt-rising bread, as he unquestionably has, has found that the factor in this salt-rising bread appears to be a bacterium hitherto wholly unrecognized by science.

I might review the work of other Fellowships with the same result.

In all the later agreements, liberty of immediate publication is provided for so long as such publication does not hurt the interest of the donors, and that we have not so far undertaken this publication is not because we do not have the material, but because I am waiting until we have collected so much of it that once beginning we can keep up a constant stream of publications relating solely to new chemical knowledge, all this quite apart from the knowledge obtained for industrial purposes.

II.- Do the Industrial Fellowships tend to promote the training of young men in chemical knowledge?

This question finds its answer in the fact that I have almost unconsciously developed these Fellowships into two distinct types:

(a) Minor Fellowships.
(b) Major Fellowships.

(a) Minor Fellowships run in remuneration from $500. to $1,000., though I now regard $750. as a minimum. They are held by young graduates of exceptional promise. The industrial research connected with each Fellowship constitutes a major in the course for the Doctorate. In these Minor Fellowships, therefore, in his research each Fellow is in precisely the same position as a regular candidate for the Doctorate in the other course. He has his minors to take care of, as well as French, German, etc. The great difference between the holder of a Minor Fellowship and a regular candidate for a Doctorate lies in the fact that his work is altogether more difficult of achievement and far more varied in character. Instead of spending two years in making up say, an indefinite number of sulphonic acids, or pyrimidenes, as the case may be, he is confronted in each case with a task of extreme difficulty in which his power of initiative is continually called into its highest exercise. Any one of these Minor Fellowships might be cited.

Thus with the investigation concerned with the extraction of real casein out of butter-milk. Casein is a phospho-protein. To begin with it was necessary for him to study all the allied substances commonly called proteins. This field in itself is extraordinarily large. Casein is a colloid, so it was necessary to go into the chemistry of colloids; the influence of electrolytes on the precipitation of colloids; the influence of soluble salts on the precipitation of casein; colloids of iron, copper and platinum were made by Bredig's method, and comparative experiments were carried out in a number of ways. The electrical charge carried by the colloid was also investigated; combustion ~~an~~ analyses were made in the ordinary way, and also combustion with Na_2O_2. The electrical conductivity of salts was determined and curves plotted; a course in bacteriology and in enzymes and fermentation was necessary, as well as in physiological chemistry; the action of the different adulterants and preservatives of milk upon casein were studied; the effect of heat of pasteurization upon casein, milk, sugar and lactic acid. The amino acids, the hydrolysis products of casein with acids and enzymes were gone into thoroughly. Casein is used in the paper, paint, dyeing and numerous other industries, and a fair knowledge of all these had to be obtained. Emil Fischer's work on the hydrolysis of proteins was studied closely. Only by comprehensive study and work of this kind was the Fellow's final success achieved.

What is true of this Fellowship is true of all the others. Instead of being narrowing the educative influence of these Fellowships is immensely broader and bigger than that pursued in the ordinary course for the Doctorate.

(b) Major Fellowships. These Fellowships for the most part yield $1,500. a year, and are held in every instance by men who have already received their Doctorate from responsible institutions and are thoroughly backed up by

Supplementary Data No. 3. Continued.

these institutions. They are distinctively strong men who have chosen to devote their lives to the investigation of the particular subject of their Fellowships. There is no criticism to be made of this because once a man has a thorough and comprehensive training his highest efficiency in most instances lies in specialization. Just as with the Minor Fellowships, however, this specialization does not mean a contraction of the man's field of knowledge but, on the contrary, means contact at every point with contemporary research.

III. Can or should the chemical manufacturers engage their own chemists to do the work which they now get done by means of these Industrial Fellowships?

In an ideal world, possibly, yes, but certainly not under conditions as they are or are likely to be. Manufacturers do not have

(1) library facilities
(2) laboratory facilities
(3) consultative facilities
(4) the advantage arising from allied researches
(5) the inspiration of an environment favorable to research.

They do have, however,

(6) factory facilities for large scale operations
(7) a knowledge of the contemporary practice of the art.

Neither in the University alone nor in the factory alone could it reasonably be expected to accomplish a tithe of what is possible through the sympathetic cooperation envolved in this method of research. We ought to be able to do, and are doing work that could not possibly be accomplished in the factory alone. The problems we are concerned with look forward to two or even three years intense effort for their solutions and with every aid that we can bring to bear from every side. Work of this kind is not possible in the present day factories in America. The University is thus able through this business of sympathetic cooperation to extend a high service to the community, for it is only through the manufacturers that any new product, or any modification of old products can go to the public.

In conclusion, it may be said in general temms that these foregoing questions may be answered by the statement that it depends on how such work is conducted.

Dr. Robert Falconer
Compliments of
The Author
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On Industrial Fellowships.

By Robert Kennedy Duncan.

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ON INDUSTRIAL FELLOWSHIPS.

In accordance with the invitation of the editor of THIS JOURNAL, I append a statement of a scheme of Industrial Fellowships which was initiated by me in an article entitled "[Temporary Industrial Fellowships," in the *North American Review* for May, 1907, and which appeared subsequently as the last chapter in a book intended to draw the attention of American manufacturers to the applicability of modern science to industrial operations ("The Chemistry of Commerce," *Harper's*). During the last two years this scheme has undergone a somewhat notable development not only in the number and value of the fellowships established, but, as well, in the increased advantages which I have found it practicable to obtain from the donating corporations in behalf of the university. It should be plainly stated, however, that the scheme is as yet inevitably experimental and tentative and that each individual fellowship must always, from the very nature of the case, be an experiment. It is not pretended either that the scheme in its details has reached its ultimate development; all that can be siad is that during the past two years it has shown no sign of weakness on the part of any one of its constituent factors but has, on the contrary, grown constantly stronger.

Before entering into the details of the scheme itself, it may be of interest to state here the fundamental considerations upon which it was based. In advancing them there is no thought of attempting to speak dogmatically; they are simply personal convictions which account for the scheme.

(1) It is not the function of a professor of industrial chemistry *in a university* to establish courses and laboratories for undergraduates who propose to become chemists, and for the following reasons: Current industrial practice is always ahead of text-book presentation and laboratories of industrial chemistry having apparatus and processes in miniature are for the most part puerile in their resultant teachings and convey to the student an exaggerated impression of his utility to the factory to which he subsequently goes. Worse than all is the fact that in taking such courses the chemical undergraduate is deprived of just so much pure chemistry, *i. e.*, real chemistry. The university insists that the chemical undergraduate shall undertake cultural and cognate studies. The result is that in taking industrial chemistry he must omit a particulary good course in physical chemistry or he must remain with half a year in organic rather than with a full year, or he must squeeze his training in combined qualitative and quantitative analysis within a year or a year and a half. If the university does not insist upon cultural studies the resultant "[Chemist]" might as well be called a cook for any claim he may have

to recognition as an educated man. The foregoing considerations do not apply to trade schools or to technical schools. The function of a university is to free men to the exercises of their maximum powers; in a trade school the young man enters already limited.

(2) Speaking with whatever truth there may be in generalities, the condition of American manufacture with respect to progressive and correct factory practice and with respect to genuine efficiency is seriously bad. (I am referring not to the mechanical but to the chemical phase of manufacture.) The necessity for this progress and efficiency in the past two or three decades has been marked by certain factors. These appear to have been a wealth of raw material everywhere at hand, an excessive tariff that concealed from the manufacture the practical presence of his problems, a certain facility possessed by the American manufacture for what may not unfairly be called business intrigue, which enabled him to supplement the waste in his factory by combinations for the elimination of competition, and, finally, the needs of a rapidly expanding population which would swallow anything. Two years ago, however, conditions were rapidly changing. The unexampled and wasteful production of the country was bidding fair to result in overproduction; in the practice of business intrigue no manufacturer had anything to learn from another; the wealth of raw material had in a large measure been aggregated into the holdings of a few men who would release them only at an onerous and distressful rate; the tariff, high as it was, was unable to exclude many articles made under scientific supervision, and the tariff, itself, lay and lies in increasingly unstable equilibrium. These facts convinced me that American manufacture was approaching a crisis and that there would soon be a realization that safety in manufacture could be gained only through efficiency. I may say here, that this conviction has been amply substantiated during the last two years. Few men have any idea of the ever-increasing anxiety of American manufacture to secure factory efficiency. It may safely be predicted that during the next five years the supply of research chemists will be wholly inadequate to the demand; it is, indeed, today.

(3) The American manufacturer has neither the knowledge nor the experience requisite for the establishment of successful scientific research.

(1) He does not know what problems he has, nor their relative importance.

(2) He does not know what kind of knowledge is required to solve these problems.

(3) He does not know how to go about it in order to obtain the men who are really expert in the different kinds of knowledge requisite to the solution of these problems.

(4) He does not know how to judge the qualifications of

training and creative power among the different men available; he frequently, for example, chooses an analyst when a synthetic man is required and *vice versa*.

(5) He does not know how to estimate a proper expenditure for laboratory space and supplies and library facilities which these men will require on the basis of the least money for the largest efficiency.

(6) He does not know how to coördinate the work of these men with the factory operations.

(7) He does not know how to coördinate the work of the researches on his staff, one with another, so that they will be mutually helpful one to another.

(8) He does not know how properly to estimate the progress made by these men so that he may know when he is getting real efficiency.

(9) He does not know how to systematize the work of his scientific staff so that it will work automatically.

(10) He does not know how to treat a man of science in his factory in giving him either power or trust.

This last consideration is responsible for much of the failure of American factory research. The condition of the research chemist in the American factory is often actually pitiful and may be compared to that of cultured governess in a home of codfish aristocracy.

Whatever the foregoing generalities may be worth, and they are, of course, merely personal convictions, they are, taken together, responsible for a scheme by which in a spirit of sympathetic coöperation the university and the manufacturer might each profit—and the public through both—a scheme of Industrial Fellowships. This scheme in its present development is perhaps best exploited by presenting here one of the later fellowships; for example, Fellowship No. 7. It will be understood that the fellowships differ one from another, owing to the particular conditions relating to each and owing, occasionally, to the idiosyncrasies of the donor.

Fellowship No. 7.—For the purpose of promoting the increase of useful knowledge, the University of Kansas accepts from the A. B. C. Glass Company, having head offices at New York, the foundation of a temporary industrial fellowship to be known as the A. B. C. Fellowship.

It is mutually understood and agreed that the conditions governing this fellowship shall be as follows:

The exclusive purpose of this fellowship is an investigation into the optical properties of glass in relation to its chemical constitution to the furtherance of which the holder shall give his whole time and attention, with the exception of three hours a week which he shall give to work of instruction in the chemical department.

The fellow shall be appointed by the chancellor of the university, the director of the chemical department and the

professor of industrial chemistry; he shall have made previously a reputation in research; he shall be a member of the university, and shall pay all regular fees with the exception of fees for laboratory and supplies, for which his instruction shall be taken in lieu, unless in the opinion of the appointers his demands become excessive, in which case the donor shall be expected to reimburse the university; he shall work under the advice and direction of the professor of industrial chemistry; and he shall forward, periodically, through the professor of industrial chemistry, reports of the progress of his work to the A. B. C. Company.

For the support of this fellowship, which shall extend through a period of two years from the date of appointment of the fellow, the A. B. C. Glass Company agrees to pay fifteen hundred dollars ($1500) per year, payable annually, to the university on the date on which the fellow begins work at the university. This sum shall be paid by the university in monthly instalments to the holder of the fellowship.

Any and all discoveries made by the fellow during the tensure of this fellowship shall become the property of the A. B. C. Glass Company, subject, however, to the pavement by them to the fellow of ten (10) per cent. of the net profits, to be commuted at the desire of either party through the arbitration provided for herein, arising from such discoveries, it being understood that the fellow shall be regarded as the inventor. At any time during the tensure of his fellowship the holder shall, at the option of the donor, take out patents at the expense of the donor on condition that at the time of making application therefor he shall assign his right to the donor under the conditions of this agreement. At or before the expiration of the fellowship, the business services of the fellow may be secured by the A. B. C. Glass Company for a term of three years on condition that the terms of such services are satisfactory to both parties at interest.

In the event of any disagreement between the donor and holder of this fellowship, it is understood and agreed that the chancellor of the university, or one whom he may appoint, shall act as arbiter as to all matters of fact, that his decisions shall be binding upon the parties at issue, and that they shall obtain such decision before having recourse to the courts.

It is also understood and agreed that during the tensure of this fellowship the holder may publish such results of his investigation as do not, in the opinion of the company, injure its interests, and that on the expiration of the fellowship the holder thereof shall have completed a comprehensive monograph on the subject of his research, containing both what he and others have been able to discover. A copy of the monograph shall be forwarded to the A. B. C. Company, and a copy shall be signed and placed in the archives of the university until the expiration of three

years from that date, when the university shall be at liberty to publish it for the use and benefit of the people.

Signed on behalf of the University of Kansas.

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Date.....

Signed on behalf of the A. B. C. Glass Company.

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Date.....

A careful reading of the above agreement, or perhaps it had better be called, memorandum, may make apparent certain relations (1) to the university; (2) to the manufacturer; (3) to the fellow; (4) to the public; (5) to the professor of industrial chemistry.

(1) (*a*) The university gains increased opportunities of fulfilling its function in promoting research. (The fact that the research has directly useful ends in view does not make it necessarily any the less scientific or valuable.) (*b*) It obtains three hours a week of gratuitous instruction from men particularly well qualified from the standpoint of ability, knowledge, and enthusiasm to give it. (*c*) The chemical department of the university obtains the catalytic influence of these men.

(2) (*a*) The manufacturer obtains the advantages of enormously increased laboratory facilities. (*b*) He obtains the advantage of adequate library facilities—a most important advantage, the lack of which has seriously hampered much factory research. (*c*) He obtains consultive advantages, for the fellow appointed is at liberty to go with direct or hypothetical questions to specialists in the different fields of chemistry or to specialists in other fields of scientific knowledge, such as biology, physiology, physics, etc. This has also turned out to be an important advantage. (*d*) He obtains a complete freedom from supervisional responsibility over this work. (*e*) He obtains on the termination of the fellowship the services of a man educated to his particular needs.

(3) The fellow obtains all the foregoing advantages (*a*–*b*–*c*) ascribed to the manufacturer, and in addition he obtains (*d*) the all-important sympathetic coöperation of the manufacturer together with the (*e*) inside knowledge of the factory processes, and (*f*) the university's environment sympathetic to research, and (*g*) a freedom from all petty interferences and jealousies of shop people, and the pot-shot judgments of factory officials. Finally, if he proves worthy of it, he obtains a position for which he has become, through his training, peculiarly qualified.

(4) Since at the end of three years all work done under any fellowship must be published free to the public, the public thus obtains new implements of civilization. It must be remembered that it is only through the industries that any useful discovery can go to the people.

(5) Since this whole scheme depends upon sympathetic

coöperation it can only be carried out through a professor of industrial chemistry who regards it as a sacred trust. It is, therefore, necessary, positively necessary that the professor of industrial chemistry should, so far as any material sense is concerned, gain absolutely *nothing*, otherwise his donors would not trust him with the details of their secret processes, nor would his fellows trust him with their progress.

There have been so far accepted by the university the following fellowships:

(1) An Investigation into the Chemistry of Laundering, having for its object an improvement which will save in some measure laundered fabrics. It yields $500 a year, together with 10 per cent. of the net profits.

(2) A Search for a New Diastase. The present source of the best diastase is expensive. The investigation has as a matter of fact developed into an attempt to make a new fodder upon scientific principles. It yields $500 a year and, under the original agreement, 10 per cent. of the gross proceeds for three years.

(3) An attempt to Utilize the Constituents of Waste Buttermilk, which, at present, in butter factories goes down the drains. These constituents, which it is desirable to conserve, are primarily caseine, and secondarily, lactic acid and sugar of milk. The fellowship yields $500 a year and 10 per cent. of the net profits.

(4) An Investigation into the Chemistry of Baking. This investigation was established by the National Association of Master Bakers, with the object not only of improving the chemistry of bread, but, as well, of providing for the association a trained expert upon whom they could afterwards rely. It yields $500 a year, together with a lump sum to be settled by arbitration, if necessary.

(5) An Investigation into the Constituents of Crude Petroleum. I cannot with propriety state the precise object of this investigation. The fellowship yields $1,000 a year, and 10 per cent. of the net profits.

(6) An attempt to Improve the Enamel upon the Enamel-lined Steel Tanks used in all kinds of chemical operations on a large scale. This fellowship was established by the largest manufacturer of these tanks in the world. It yields $1,300 a year, together with an additional consideration to be decided upon, for the service rendered by the chancellor of the university or one whom he may appoint.

(7) An Investigation into the Relation between the Optical Properties of Glass and Its Chemical Constitution. This fellowship yields $1,500 a year and 10 per cent. of the net profits.

(8) The Discovery of New Utilities for Portland Cement and of Improvements in Its Manufacture. This fellowship yields $1,500 a year and a large additional consideration dependent upon success.

The fellows for additional Fellowships Nos. 7 and 8 have not yet been selected. In addition to the foregoing fellowships there are certain others assured but not yet established.

(9) An Investigation into Certain Glands of Deep-sea Mammals. It yields $1,500 a year and an additional consideration to be decided upon by arbitration. This fellowship is to be a benefaction.

(10) The Discovery of New Utilities for Ozone. It yields $2,000 a year and 10 per cent. of the net profits.

The tensure of all fellowships is two years.

It is regrettable that in accordance with the terms of the agreement, it is impossible to publish at this time the results so far obtained. It may be said, however, that the progress of the fellows has been gratifying. It is significant in this connection that Fellowship No. 1, which expires shortly, is to be continued at double the value for three months, at the end of which time the donors will either take the fellow and his process into the factory or they will continue his fellowship through a third year at the increased amount, while with Fellowship No. 2 the donors have already indicated their intention to continue it throughout a third year; the progress of the others has exceeded that of the first two and has surpassed expectations.

Most of these fellowships have arisen through letters of inquiry from the various companies. I have not gone out seeking fellowships in general. Had I done so it is not unreasonable to suppose that by this time there might have been from thirty to fifty. Owing to the fact that these fellowships have no relation to ordinary fellowships and that the scheme is essentially a new one, it has been deemed advisable to establish them at intervals. Proceeding in this way, and learning as one went, the scheme has undergone a natural and advantageous development. The degree to which it has been systematized, its effect upon the chemical department, the results of the relations of the different researches and researches to one another, and the wholly unexpected interactional relation to the donating companies to one another I shall reserve for a future communication. While it should be said that as yet this scheme of Industrial Fellowships is wholly experimental and tentative, it ought also to be said that the two years' experience has not shown that it is any other than a sane and practical relation between the university and industry to the advantage of all concerned.

ROBERT KENNEDY DUNCAN.

UNIVERSITY OF KANSAS,
May 12, 1909.